INDOOR AIR QUALITY ASSESSMENT

Augustine Belmonte Middle School
25 Dow Street
Saugus, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Deborah Rosati, Director of the Saugus Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Belmonte Middle School, Saugus, MA. Concerns regarding the hospitalization of a student attending this school and indoor air quality prompted the inspection.

BEHA staff were specifically requested to examine classrooms 109-112, 247 and 316 for sources of microbial growth and other potential factors that could adversely affect indoor air quality. In addition, BEHA staff were asked to examine conditions of crawlspaces that are located beneath each wing of the school. Conditions seen in these areas were discussed in a previous letter to the Saugus Board of Health (MDPH, 2002a). This report describes general indoor air quality conditions observed during the visit.

On October 10, 2002, Mike Feeney, Director of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program conducted the assessment. Mr. Feeney was accompanied by Cory Holmes, an Environmental Analyst in BEHA's ER/IAQ program; Kevin Nigro, Director of Inspectional Services; David Jackson of the Saugus School Committee; Corey Fanjoy, school custodian and Ms. Rosati.

The school consists of two sections, the north and south wings. The south wing had a crawlspace that regularly accumulated water and was the focus of concern examined in a previous BEHA assessment. The school was previously visited by BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, in February 2000 to conduct a general indoor air quality assessment and in February 2002 to conduct a limited assessment involving carbon monoxide and soot deposition. Reports were issued (MDPH, 2000 and MDPH, 2002 respectively) which described the conditions of the building at that time. The reports showed that there were problems identified and gave recommendations on how to correct those problems. The building was more recently evaluated by OccuHealth, Inc., a private consultant in October of 2001 retained to conduct airborne mold testing. The OccuHealth report showed levels of mold elevated above background in the crawlspace and made the following recommendations:

1. Continuously dewater the crawlspaces to prevent water accumulation.
2. Professionally treat the crawlspace with a biocide to kill the mold.
3. Continuously ventilate and dehumidify the crawlspace.
4. Replace the dirt floor of the crawlspace with concrete (OccuHealth, 2001).

The school took additional steps to remove pipes and other utilities from the crawlspace and fill it with concrete to form a slab (see Picture 1). Pipes and other utilities were installed along the ceiling of first floor classrooms (see Picture 2). OccuHealth retested the crawlspace as well as a number of classrooms in September of 2002 following remedial actions and found mold levels in all areas below background (OccuHealth, 2002).

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for ultrafine particulates were taken with the TSI, P-Trak ™ Ultrafine Particle Counter, Model 8525. Screening for total volatile organic compounds (TVOCs) was conducted using an HNU

Systems, Photo Ionization Detector (PID). Outdoor background TVOC measurements were taken for comparison to indoor levels. No levels of TVOCs UFPs or CO were measured above background levels in occupied areas.

Results

This school is currently housing a student population of approximately 1000 and a staff of approximately 100. The tests were taken during normal operations at the school. Test results appear in Tables 1-2.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm (parts per million) in four of the six classrooms surveyed, indicating inadequate air exchange in these areas of the school. It should also be noted that these classrooms were empty or sparsely populated, which further indicates little or no air movement.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Figure 1). Univents were found deactivated in several areas. The univent in classroom 110 was reportedly on work order to be repaired. In order for univents to provide fresh air as designed, these units must remain activated while classrooms are occupied.

Exhaust ventilation in classrooms is provided by unit exhaust ventilators. Exhaust ventilators were also not operating in some of the areas surveyed at the time of the assessment. As with the univents, in order for exhaust ventilation to function as designed, unit exhaust ventilators must be activated.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself at levels measured in this building. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings ranged from 65 ^{0}F to 74 ^{0}F, which were below BEHA's recommended comfort guidelines in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{0}F to 78 ^{0}F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measurements in the building ranged from 40 to 50 percent, which were within the BEHA recommended comfort range in all areas surveyed. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Humidity is more difficult to control during the winter heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several conditions were observed which appear to enhance water impact upon the south wing. The front of the building has a driveway and is several feet above the level of the lowest floor of the south wing. Land between the driveway and south wing slab *slopes toward* the building (see Picture 3). Water appears to accumulate in a corner formed by the south wing and the front walkway of the building (see Picture 4) coming in contact with the slab as indicated by the lack of grass growing in the corner as well as along the foundation/slab. Several other features tend to enhance the collection of water in this corner.

1. A downspout that serves as a roof drain empties directly into the corner (see Picture 4),
2. Several trees grow in this corner (see Picture 4). Plant roots tend to accumulate water. Tree roots that extend from the trunk can serve a conduit for water to travel. The presence of trees can both hold water in and direct water towards the foundation.
3. While a drain is located within this lawn (see Picture 5), it is above the lowest point of this area.

Over time, these conditions can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001). This may also allow for water to gather beneath the slab.

A similar condition exists along the rear exterior wall of the south wing. A small lawn exists immediately adjacent to the slab (see Picture 6). Moist weather tends to travel in a northeasterly track up the Atlantic Coast towards New England (Trewartha, G.T., 1943). Wet weather systems generally produce south/southwesterly winds, which will directly strike the west exterior wall of the south wing. Rainwater runoff from the west exterior wall runs onto this lawn and pools. Over time, the impact of water has eroded soil, creating depressions in the grass that accumulate water (see Picture 7). Enhancing water accumulation is another roof drainage downspout that empties onto this lawn (see Picture 8). No drains exist in this lawn area. The closest drain is located over one hundred feet west of the south wing in a ball field (see Picture 9). While the tarmac is leveled towards this drain, away from the south wing, plant growth along a guardrail at the edge of a driveway between the drain and the school has created a berm, which prevents water drainage. The existence of lawns at the front of and behind the south wing combined with roof drains emptying near the foundation create conditions to allow water to pool against the foundation.

The west exterior wall of the south wing was also examined. It appears the rainwater striking the wall splashes onto the lip of the foundation, which extends several inches out from the line of the wall. Located at the base of the foundation are univent fresh air intakes (see Picture 10). The location of the fresh air intakes may make these vents prone to moisture exposure and accumulation of outdoor debris. The interior of univent fresh air intakes could not be examined since each grill was tightly caulked into place. If water moistens accumulated outdoor debris within the fresh air intake, this material may support mold growth.

Active mold growth was observed on tiled walls in the shower area of the boy's locker room. The characteristic pattern on walls and the floor directly below indicate that the showerheads are leaking (see Picture 11). Microbial growth can be a source of irritation for sensitive individuals.

The crawlspace in the corner of the girl's locker room/shower area was examined. Several inches of standing water was observed and strong odors were detected upon opening the access plate (see Picture 12). Standing water can become stagnant, which can lead to mold, bacterial, or other microbial growth that can be a source of unpleasant odors.

Signs of bird roosting and nesting materials were observed in the gymnasium air intake louvers on the exterior of the building (see Picture 13). If the ventilation system is activated, the possibility exists for nesting materials, bird waste and other related particulate to be drawn into the system and be distributed to occupied areas. Birds can be a source of disease, and bird wastes and feathers can contain mold and mildew, which can be irritating to the respiratory system.

Certain molds are associated with bird waste and are of concern for immune-compromised individuals. Other diseases of the respiratory tract may also result from chronic exposure to bird waste. Exposure to bird wastes is thought to be associated with the development of hypersensitivity pneumonitis in some individuals. Psittacosis (bird fancier's disease) is another condition closely associated with exposure to bird wastes in either the occupational or bird raising setting. While immune-compromised individuals have an increased risk of health impacts following exposure to the materials in bird wastes, these impacts may also occur in healthy individuals exposed to these materials.

The methods to be employed in clean up of a bird waste problem depend on the amount of waste and the types of materials contaminated. The MDPH has been involved in several indoor air investigations where bird waste has accumulated within ventilation ductwork (MDPH, 1999). Accumulation of bird wastes have required the clean up of such buildings by a professional cleaning contractor. In less severe cases, the cleaning of the contaminated material with a solution of sodium hypochlorite has been an effective disinfectant (CDC, 1998). Disinfection of non-porous materials can be readily accomplished with this material. Porous materials contaminated with bird waste should be examined by a professional restoration contractor to determine if the material is salvageable. Where a porous material has been colonized with mold, it is recommended that the material be discarded (ACGIH, 1989).

The protection of both the cleaner and other occupants present in the building must be considered as part of the overall remedial plan. Where cleaning solutions are to be used, the "cleaner" is required to be trained in the use of personal protective methods and equipment (to prevent either the spread of disease from the bird wastes and/or exposure to cleaning chemicals). In addition, the method used to clean up bird waste may result in the aerosolization of particulates that can spread to occupied areas via openings (doors, etc.) or by the ventilation system. Methods to prevent the spread of bird waste particulates to occupied areas or into ventilation ducts must be employed. Given that containment procedures warranted are similar to those used to contain the spread of renovation-generated dusts and odors in occupied areas, the cleaner should employ the methods listed in the SMACNA Guidelines for Containment of Renovation in Occupied Buildings (SMACNA, 1995). A copy of an issue of the Centers for Disease Control Morbidity and Mortality Weekly Report for July 10, 1998, which covers the clinic aspects as well as clean up associated with bird waste, is included as Appendix II.

Reports of flooding in the rear stairwell were expressed to BEHA staff (see Picture 14). The drain located at the base of the stairwell was completely clogged with debris (see Picture 15). Also noted on the rear of the building were missing downspouts (see Picture 16). Gutters and downspouts are designed to collect rainwater and divert them away from the building. Improper drainage and/or missing downspouts can allow water accumulation against the building.

Cracks in exterior walls and crumbled damaged caulking around univent air intakes were noted on the exterior of the building (see Pictures 17 & 18). These breaches in the building envelope can also be potential sources of water penetration leading to water damage and or microbial growth to porous materials.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Of note was the detection of airflow from seams between walls beneath the stairwell to the south wing (see Picture 19). Similar airflow from holes around retrofitted HVAC system pipes were noted in a classroom that shares the stairwell wall (see Picture 20). This airflow was traced to a crawlspace that connects to the boiler room. This crawlspace was dry and no odors were detected by BEHA staff within the crawlspace. As part of the remediation of the boiler room, improved make up air vents to aid boiler combustion were rehabilitated. The opening to the crawlspace exists in the boiler room (see Picture 21). A northwest wind was detected by BEHA staff, which enters the boiler room, pressurizes the area, and creates drafts in the crawlspace which forces air through the seams noted beneath the stairwell and in the classroom. Crawlspace air entering occupied areas should be prevented.

Finally, a can of latex paint was stored in a cabinet at the front of the classroom. The can was not properly sealed which can allow off-gassing paint fumes and volatile organic compounds (VOCs) into the classroom (see Picture 22), providing a source of eye and respiratory irritation.

Conclusions/Recommendations

In view of the findings at the time of this assessment, the following recommendations are made:

1. Continue to implement the recommendations made in the previous BEHA reports.
2. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy *independent* of classroom thermostat control.
3. Once both the fresh air supply and exhaust ventilation are functioning, the systems should be balanced by a ventilation engineer.
4. Install gutters and downspouts to direct rainwater at least five feet away from the foundation. In the case of the front of the south wing, extension of the downspout to empty over the curb is advised.
    a. Remove the trees from the front lawn of the south wing. Foliage should be at least five feet away from the foundation.
    b. Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek, J. & Brennan, T.; 2001).

c. Consideration should be given to re-grading the front lawn and lowering the level of storm drain to enhance drainage should be considered.

d. Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek, J. & Brennan, T.; 2001). This may include paving over the small lawn at the rear of the south wing.

e. Remove the accumulated materials beneath the guardrail to enhance water drainage.

5. Examine the feasibility of extending downspouts to ground level and directing water away from the base of the exterior wall.

6. Fresh air intakes at ground level should be opened and examined. Clean debris if present. Consideration should be given to installing a hood or other device over ground floor univent fresh air intakes to prevent rainwater intrusion.

7. Take measures to prevent water intrusion through the building envelope. This may include sealing cracks along the foundation/exterior walls, repairing damaged brickwork and sealing around univents and wall/foundation junctions with an appropriate sealing compound.

8. Seal wall seams beneath the stairwell and pipe penetration from the crawlspace.

9. Construct a wall over crawlspace entrances in the boiler room.

10. Have a complete inventory done in all storage areas and classrooms. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets

(MSDS') for chemicals from manufacturers or suppliers. Be sure all materials are labeled clearly.

11. Remove birds' nests from fresh air intake vents and clean with an appropriate antimicrobial. If bird nesting/waste contamination is determined to be extensive consider contacting a professional cleaning company. Consider installing wire mesh bird screens over gymnasium air intakes to prevent further roosting (see Picture 23.

12. Unclog drain in rear entrance way and ensure proper drainage. Inspect periodically to maintain drainage.

13. Continue to examine methods to eliminate water accumulation in the crawlspace, or take measures to create an airtight seal between the crawlspace and occupied areas.

14. Clean mold growth in shower areas and repair leaking shower fixtures. Ensure local exhaust vents are activated when showers are in use to remove excess heat and moisture.

15. Repair/replace broken and/or loose windows and replace missing or damaged window caulking to prevent water penetration through window frames.

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Picture 1

Former Utility Pipe Holes Filled with Concrete

Picture 2

New Installed HVAC System Pipes

Picture 3

Front Lawn of South Wing the Slopes toward the Foundation

Picture 4

Corner of Front Lawn Prone to Water Accumulation, Note Downspout and Locate of Trees

Picture 5

Front Lawn Drain Overgrown by Grass

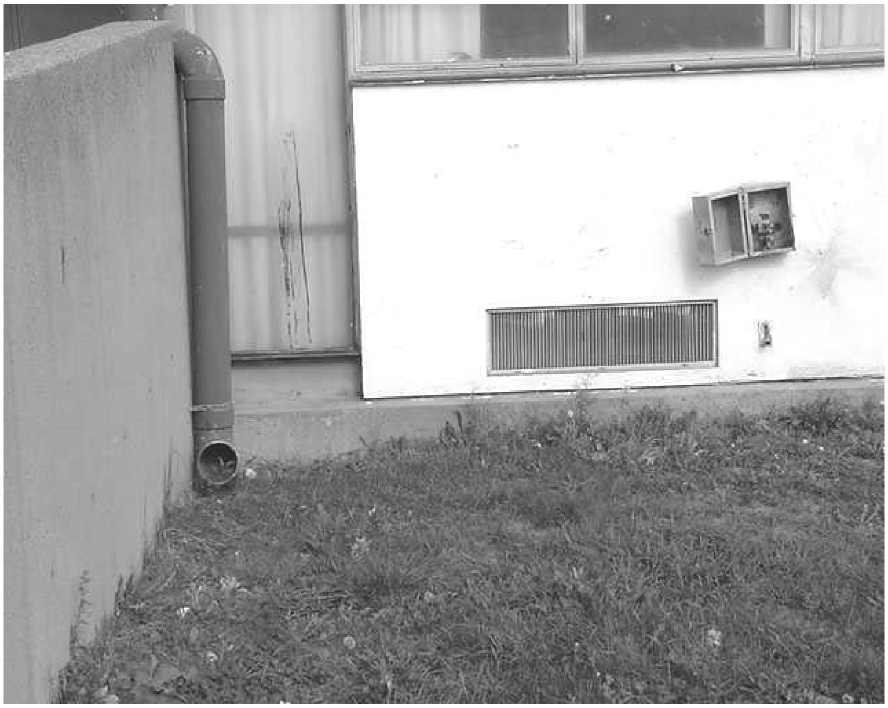
Picture 6

Small Lawn at Rear of South Wing

Picture 7

Water Furrowed Depressions along West Exterior Wall of South Wing

Picture 8



Downspout That Empties Onto Rear Lawn of South Wing

Picture 9

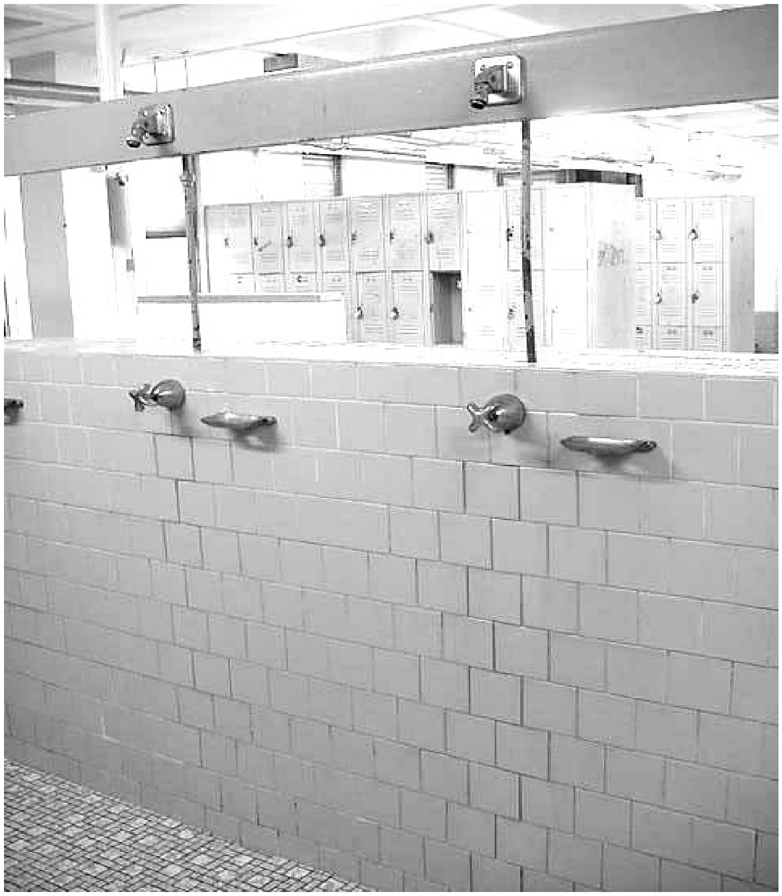
Storm Drain

Storm Drain in Field, Note Berm Created by Vegetation below Guardrail, Creating a Dam

Picture 10

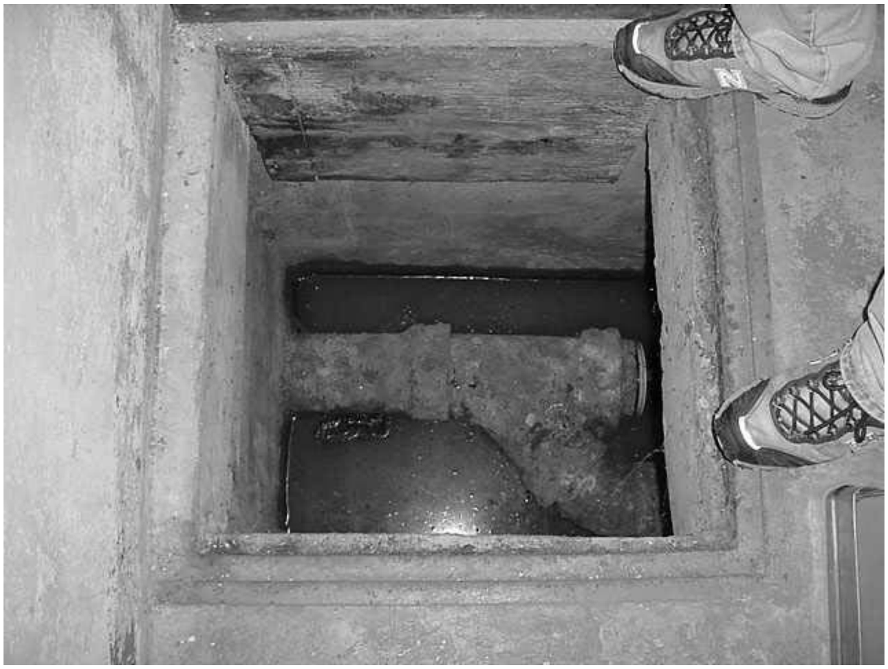
Fresh Air Intake Vents at Base of South Wing West Exterior Wall, Note Water Damage at Base of Grille

Picture 11



Leaking Shower Heads and Mold Growth between Wall Tiles in Boy's Locker Room

Picture 12



Standing Water in Girls Locker Room Crawlspace

Picture 13

Birds Nests and Wastes in Gymnasium Fresh Air Intake

Picture 14

Rear Entrance Prone to Flooding, Arrow Indicates Drain

Picture 15

Close-Up of Clogged Drain (In Previous Picture) For Rear Entrance

Picture 16

Missing Downspout, Note Water Staining on Wall

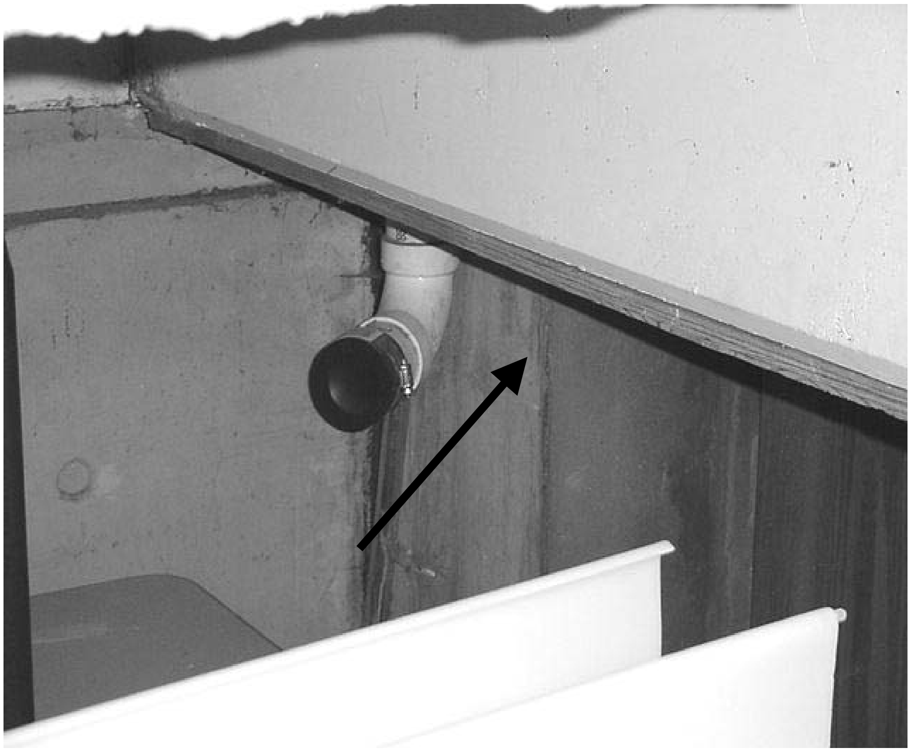
Picture 17

Crack in Exterior Wall, Spaces around Dried out Caulking Univent Air Intake

Picture 18

Damaged Exterior Wall, Dried Out/Crumbling Caulking Around Univent Air Intake

Picture 19



Seam in Walls beneath South Wing Stairwell

Picture 20

Spaces around HVAC System Pipes

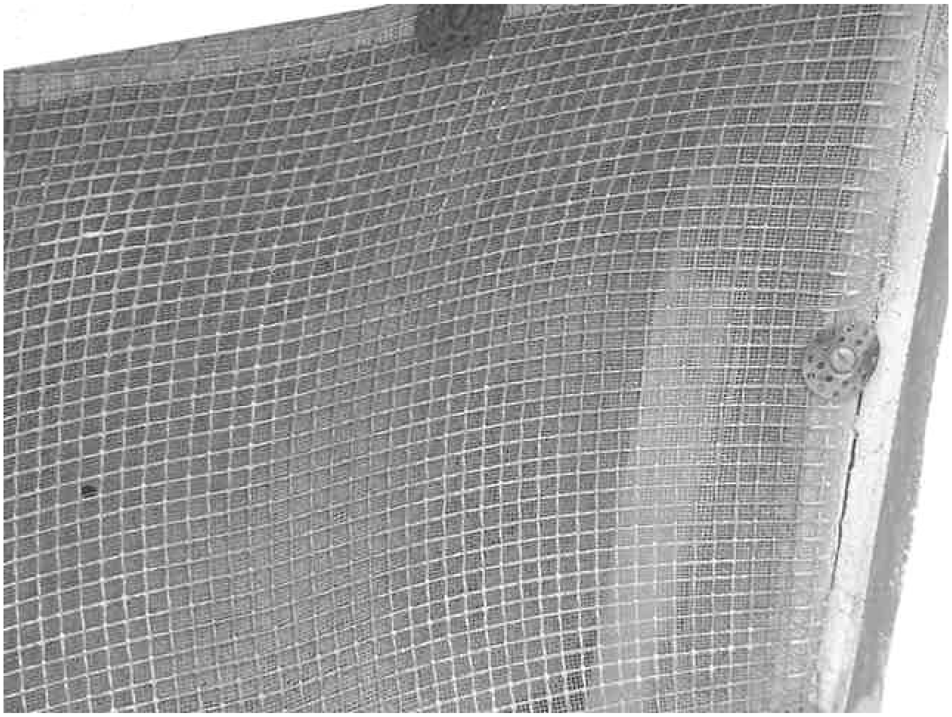
Picture 21

Opening To Crawlspace in Boiler Room

Picture 22

Latex Paint Not Properly Sealed Found In Classroom Cabinet

Picture 23



Wire Mesh Screen Installed over Univent Fresh Air Intake

TABLE 1

Indoor Air Test Results – Belmonte Middle School, Saugus, MA – October 10, 2002

Location	Carbon Dioxide *ppm	Carbon Monoxide *ppm	TVOCs *ppm	Ultra-fine Particulate	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Background	284	0	0.0-0.2	4.5-6.0	65	48					Overcast, light breeze
Main Hallway	320	0	0.0	4.8-5.2	67	49					
Main Hallway (crawlspace)	480	0	0.0	5.6	68	43					Crawlspace not filled in this area
Boiler room	550	0	0.0	17.6	74	42					Boilers/Furnaces in operation
Art (101)	644	0	0.0	3.8	68	50	0	Y	Y	Y	Crawlspace filled, univent (UV) and exhaust -on
Hallway outside 101	580	0	0.0	2.9			0				
110	1261	0	0.0	3.0	71	42	0	Y	Y	Y	28 occupants gone 1 min, UV noisy, grill broken on work order to be repaired, latex paint under cabinet-not properly sealed, potting soil under cabinet
109	906	0	0.0	2.8	70	45	0	Y	Y	Y	Occupants gone 10 min (20-25)

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Belmonte Middle School, Saugus, MA – October 10, 2002

Location	Carbon Dioxide *ppm	Carbon Monoxide *ppm	TVOCs *ppm	Ultra-fine Particulate	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
									Intake	Exhaust	
111	1096	0	0.0	2.7	71	46	0	Y	Y	Y	Occupants gone 30 min, UV-off
112	862	0	0.0	3.5	72	43	1	Y	Y	Y	
316	443	0	0.0	2.1	69	41	1	Y	Y	Y	
247	699	0	0.0	5.1	70	42	11	Y	Y	Y	Exhaust & UV-off
Boy's Locker Room	580	0	0.0	2.0	67	42	0		Y	Y	No working exhaust vents, 11 of 19 showers leaking, mold growth on wall/floor tile
Gym	480	0	0.0	1.9	65	40	0	N	Y	Y	
Girls Locker Room	490	0	0.0	2.0	66	44	0		Y	Y	Stagnant water in crawlspace in corner-odors

*** ppm = parts per million parts of air**
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